ORIGINAL ARTICLE

Prevalence of overweight, obesity and low weight in the Czech child population up to 18 years of age in the last 50 years

J. Vignerová · L. Humeníková · M. Paulová · J. Riedlová

Abstract

Aim The main purpose of the study was to analyze the changes in the prevalence of underweight, overweight, and obesity among Czech children and adolescents aged 3–18 within the last 50 years. The secondary purpose of the study was to determine the prevalence of overweight and obesity among children and adolescents in 2001 and compare it to the reference standards recommended by the International Obesity Task Force (IOTF).

Subject and methods Anthropometric data collected from nationally representative samples of 3–18-year-old children and adolescents in the Czech Republic in 1951, 1981, 1991, and 2001 were analyzed in the study. The prevalence of child overweight and obesity among Czech children using data from the most recent 2001 National Anthropological Survey was estimated using the 1991 Czech reference values and the IOTF standards.

Results There has been a gradual increase in the number of children in both extreme categories of BMI values in most age categories, including underweight (<10th percentile), overweight (>90th percentile), and obesity (>97th percentile) between 1951 and 2001. In both genders, the number of underweight children increased dramatically in the lowest age categories. At the same time, the rates of overweight and obesity increased among 6–11- and 11–15-year-old individuals. The prevalence of underweight has also increased among older adolescents. However, our study indicated that the 2001 prevalence of overweight/obesity among Czech adolescents, especially in older age categories and among girls, was lower compared to the 1991 reference values.

Conclusion Given the continuous increase in child obesity rates in the US and most of Europe, it is interesting that the prevalence of overweight and obesity has remained relatively low among children and adolescents in the Czech Republic. Given the increased number of Czech school-aged children with excess adiposity, a gradual rise in the prevalence of overweight and obesity among Czech adolescents could be expected.

Keywords Underweight · Overweight · Obesity · Prevalence · Czech Republic

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Introduction

In the last several decades, obesity has become one of the most prevalent chronic diseases in the developed world, and the rates of obesity continue to rise in many countries (Jackson-Leach & Lobstein 2006). While genetic background may influence the development of excessive adiposity, researchers agree that other factors, such as

parental food habits and weight status, physical activity, socio-economic status, and breast feeding, play more important roles in obesity prevention and development than individuals' genetic makeup (Rennie et al. 2005). For instance, the global increase in the prevalence of obesity is largely contributed to by a gradual increase in energy intakes and a decrease in physical activity over the last 30 years (Institute of Medicine 2002; Reilly 2007). These and other changes in individuals' behaviors and lifestyle have contributed to a positive energy balance and thus the increased prevalence of obesity in many developed countries around the world (Reilly 2007).

While obesity represents a serious health risk in adult populations, the consequences of excessive adiposity are even more alarming for children. Children who become overweight early in life are more likely to become overweight as adolescents and adults (Reilly et al. 2003). Furthermore, the risk of developing obesity-related health problems is substantially higher for children with excess adiposity compared to non-overweight children (Reilly 2007; Reilly et al. 2003).

To date, the prevalence of child overweight is highest among American children, with nearly 32% of 6–19-year-old children being overweight or at risk for overweight (Hedley et al. 2004). In contrast to the alarming rates of child overweight in the US and several European countries, children in the Czech Republic have relatively low rates of overweight and obesity (Kobzova et al. 2004). The Czech Republic, a former communist country in Eastern Europe, has a long tradition of national anthropometric surveys that allow for a continuous monitoring of growth and development of Czech children and adolescents. The first national anthropological survey of children and adolescents with a major focus on health and nutritional status was conducted in 1951. The subsequent national surveys were conducted at 10-year intervals to primarily provide the reference data and growth charts for basic body parameters of the Czech population of children and adolescents from 0–18 years of age. The latest survey was the 6th National Anthropological Survey (NAS) and was conducted in 2001 (Kobzova et al. 2004).

The current weight status of Czech children and adolescents is determined using the growth charts that were constructed based on the results of the 5th NAS in 1991 (Lhotská et al. 1993). Due to the increasing prevalence of child overweight and obesity between 1991 and 2001, the reference standards were not updated based on the latest 6th NAS in 2001 (Vignerová 2006b). Because population-based growth charts and reference standards are currently used in the Czech Republic, the BMI values associated with the cut-offs for overweight and obesity differ from the BMI values that were established by the International Obesity Task Force (IOTF) as an international standard for child

overweight in 2000 (Cole et al. 2000). Thus, the prevalence of obesity as well as comparisons between Czech children and children from other countries is influenced by the type of reference standards that are used for identifying overweight and obese individuals.

Given the unique anthropological data available in the Czech Republic, the main purpose of the study was to analyze the changes in the prevalence of underweight, overweight, and obesity among Czech children and adolescents aged 3–18 within the last 50 years. The secondary purpose of the study was to determine the prevalence of overweight and obesity among children and adolescents in 2001 and compare it to the reference standards recommended by the IOTF (Cole et al. 2000).

Methods

Anthropometric data collected from nationally representative samples of 3–18-year-old children and adolescents in the Czech Republic in 1951, 1981, 1991, and 2001 were analyzed in the study. The first post–World War II nationwide anthropological study of children and adolescents was carried out in 1951. While the subsequent anthropometric measures were collected from children and adolescents at 10-year intervals, raw data from 1961 and 1971 were not available for the analysis. The number of children investigated in each survey represented approximately 3–5% of the children population in a given age category (Table 1). The most recent anthropometric survey (the 6th National Anthropometric Survey) was conducted in 2001 (Vignerová et al. 2006b).

Data on height, weight, and other anthropometric characteristics were collected during each of the four National Anthropological Surveys. Children's anthropometric characteristics were measured in a variety of settings depending on the age of the participating children. Preschool children were evaluated by pediatricians at health-care facilities, while school-aged children were measured by teachers and university students of anthropology at schools. Both pediatricians and teachers were provided with written instructions and anthropology students were carefully trained by professional anthropologists before the data collection (Kobzová et al. 2004). A

Table 1 The number of subjects included in the study analysis

Year of the survey	1951	1981	1991	2001
Boys				
Age 3–18 years	48 173	37 896	30 980	19 505
Girls				
Age 3–18 years	44 251	37 354	32 084	22 232

questionnaire containing items related to the socio-economic status, parental education, family size, parental BMI, and other variables was administered to parents or children during each of the national surveys.

Due to the increased prevalence of child obesity identified in the 2001 National Anthropological Survey, the weight status of children and adolescents in the Czech Republic is currently determined using the growth charts that were constructed utilizing the LMS method (Cole et al. 1998) based on the results of the 5th National Anthropological Survey in 1991 (Lhotská et al. 1993). The BMI-for-age percentile of 90 is presently used as a cut-off for child overweight, and the BMI-for-age percentile of 97 is used to identify obese children. Children whose BMI-for-age is below the tenth percentile are considered underweight. These cut-offs were used to classify children and adolescents as underweight, normal weight, overweight, or obese.

International reference standards for determining child overweight were developed by the International Obesity Task Force (IOTF) in previous research (Cole et al. 2000). The BMI values corresponding to the 90th and 97th percentile cut-offs differ between the Czech reference standards and the IOTF recommendations, especially at the 97th percentile that indicates child obesity (Table 2, 3). Because significant differences exist among the Czech and the IOTF reference standards, the prevalence of child overweight and obesity among Czech children using data from the most recent 2001 National Anthropological Survey was estimated using both the 1991 Czech reference values and the IOTF standards.

Results

The comparison of the BMI values corresponding to the 10th, 50th, and 90th between the 1951 and 1991 growth charts is shown in Fig. 1 and 2. The range of the BMI values corresponding to the underweight and overweight/obese percentile categories expanded, with the exception of

Table 2 Cut-off points for selected age by the 1991 Czech references and the IOTF recommendations among boys

Age (years)	90th centile cut-off points		97th centile cut-off points	
	Czech[I]	IOTF[II]	Czech[I]	IOTF[II]
3	17.9	17.9	19.1	19.6
6	17.6	17.6	18.9	19.8
11	20.8	20.6	23.3	25.1
15	23.5	23.3	25.9	28.3
18	25.4	25.0	27.7	30.0

[I] Lhotska et al. 1993
[II] Cole et al. 2000

Table 3 Cut-off points for selected age by the 1991 Czech references and the IOTF recommendations among girls

Age (years)	90th centile cut-off points		97th centile cut-off points	
	Czech[I]	IOTF[II]	Czech[I]	IOTF[II]
3	17.5	17.6	18.5	19.4
6	17.6	17.3	18.9	19.7
11	20.9	20.7	23.3	25.4
15	23.6	23.9	26.0	29.1
18	25.0	25.0	27.6	30.0

[I] Lhotska et al. 1993
[II] Cole et al. 2000

adolescent girls, between 1951 and 1991, indicating that the prevalence of underweight as well as overweight/obese children have increased in the Czech Republic in the last several decades (Vignerová et al. 2007). As indicated in previous research, the results showed significant changes in BMI values at the 50th percentile and a shift of adiposity rebound to earlier ages among Czech children since 1951 (Vignerová et al. 2006a).
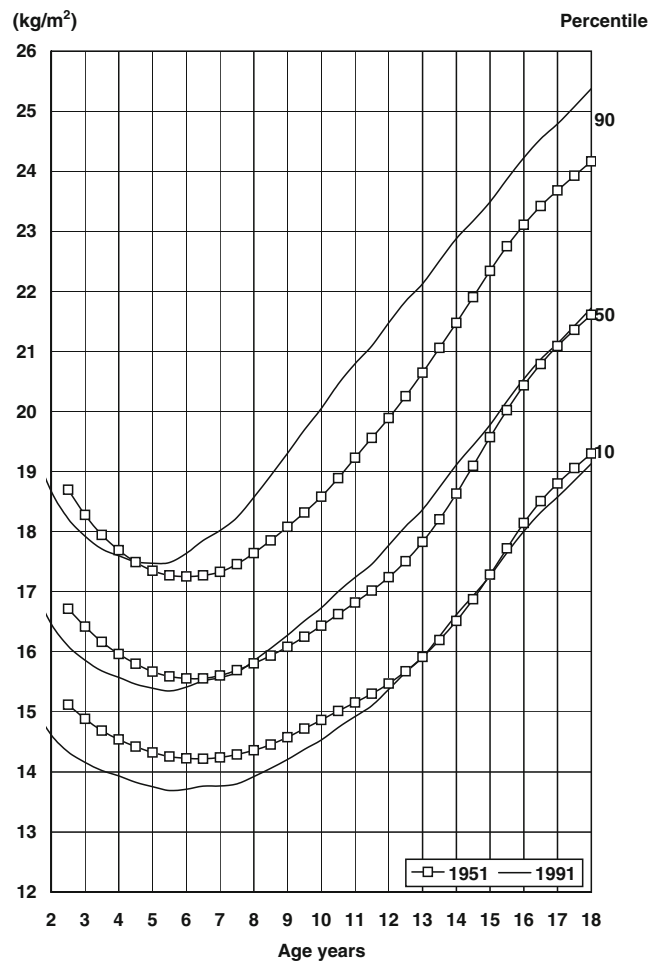

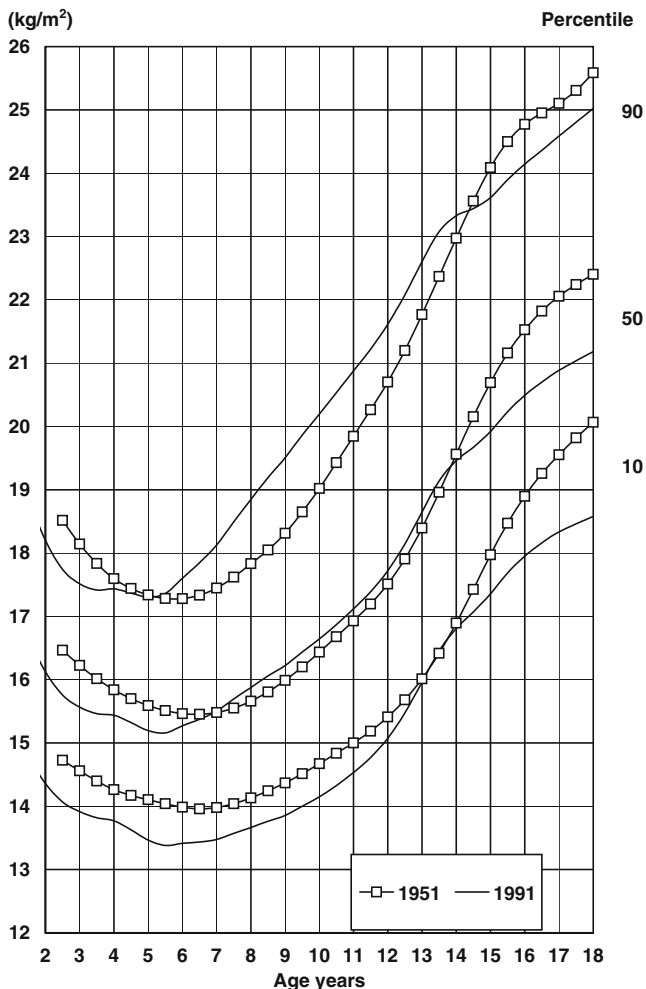**Fig. 1** BMI centile charts. 1951 and 2001 comparison. Boys

Fig. 2 BMI centile charts. 1951 and 2001 comparison. Girls

The prevalence of underweight, overweight, and obesity among Czech children and adolescents in each of the four national surveys, according to individual ages, is shown in Tables 4, 5. Because the results of the 1991 survey were used for establishing the Czech reference standards (Lhotska et al. 1993), the number of children and adolescents in each weight category was constant in 1991 across the age and gender categories, with 10% of children being underweight, 7% overweight, and 3% obese.

The overall prevalence of underweight, normal weight, overweight, and obesity in the combined age categories from the 1951, 1981, and 2001 National Anthropological Surveys is shown in Tables 4 and 5. The results of our analysis indicated that there has been a gradual increase in the number of children in both extreme categories of BMI values in most age categories, including underweight (<10th percentile), overweight (>90th percentile), and obesity (>97th percentile) between 1951 and 2001.

In both genders, the number of underweight children increased dramatically in the lowest age categories. At the same time, the rates of overweight and obesity increased among 6–11- and 11–15-year-old individuals (Table 4, 5). The prevalence of underweight has also increased among older adolescents. This trend is particularly apparent among adolescent girls where the prevalence of underweight increased from 3.7% in 1951 to 10% in 1991 and 13.3% in 2001 (Table 5). As the number of underweight girls increased, the prevalence of overweight and obesity in the adolescent category have decreased from 14.6% in 1951 to 8.5% in 2001 (Table 5). The reported changes were confirmed by statistically significant odd ratios that were related to the reference values from 1991 (Lhotská et al. 1993).

Given the significant differences between the 1991 Czech and the IOTF standards, the prevalence of overweight and obesity among Czech children was compared by gender using both sets of the reference values (Table 2, 3). The results of our study indicated that the use of the international reference values led to an increase in the number of Czech children that were categorized as overweight and a decrease in the number of children that were found to be obese. Using the IOTF reference standards, the prevalence of obesity among Czech children in 2001 thus exceeded the expected 3% from 1991 only among 3–11-year-old boys and girls (Table 6, 7). In addition, only 0.8% of 15–18-year-old adolescent girls were identified as obese in 2001 based on the IOTF reference values (Table 6). According to the 1991 Czech reference values, the prevalence of obesity among Czech children exceeded 3% in both genders and all age categories, with the exception of 15–18 year old girls, where the prevalence of obesity was 2.5% (Table 7).

Discussion

The main purpose of the study was to identify changes in the prevalence of underweight, overweight, and obesity that have occurred among Czech children and adolescents from 1951 to 2001 and compare them to the 1991 Czech growth reference standards. The results of our study clearly indicated that dramatic weight-related changes have occurred among children in the Czech Republic in the last several decades. As the prevalence of the obesity epidemic continues to increase in the US and many European countries, the Czech children population has experienced a variety of growth-related changes since 1951.

Our study builds upon previous research that closely investigated historical and anthropological trends related to the growth and development of the child population in the Czech Republic within the past 50 years (Vignerová et al. 2006a). A shift of adiposity rebound to lower age categories and earlier occurrence of puberty among both Czech boys

Table 4 The prevalence of underweight, normal weight, overweight, and obesity among boys by age groups in 1951, 1981, and 2001 as compared to the 1991 Czech references (Lhotská et al. 1993)

Age years	Numbers	BMI categories (%, OR)			
		<10th percentile Underweight	10th–90th percentile Normal	90th percentile < Overweight and obese	97th percentile< Obese
1951 survey					
3.00–5.99	7680	5.1 [0.53 **]	86.8	8.1 [0.84 **]	2.1
6.00–10.99	12,126	5.3 [0.53 **]	90.0	4.7 [0.47 **]	1.4
11.00–14.99	21,180	9.9 [1.04 n.s.]	86.0	4.1 [0.43 **]	1.0
15.00–17.99	7,187	8.7 [0,91 n.s.]	86.9	4.5 [0.47 **]	0.9
1981 survey					
3.00–5.99	10,523	10.0 [1.09 n.s.]	82.8	7.2 [0.78 **]	2.1
6.00–10.99	11,324	7.4 [0.80 **]	83.0	9.5 [1.03 n.s.]	3.5
11.00–14.99	8,733	10.2 [1.15 **]	79.9	9.8 [1.10 *]	3.1
15.00–17.99	7,316	8.7 [0.93 n.s.]	83.9	7.5 [0.81 **]	2.4
2001 survey					
3.00–5.99	2,103	14.1 [1.66 **]	76.6	9.2 [1.08 n.s.]	4.6
6.00–10.99	5,930	7.5 [0.88 *]	77.0	15.5 [1.81 **]	6.6
11.00–14.99	6,341	9.5 [1.13 *]	75.7	14.9 [1.77 **]	5.6
15.00–17.99	5,131	11.9 [1.37 **]	78.6	9.5 [1.09 n.s.]	3.6

n.s.-non significant

* $p < 0.05$

** $p < 0.01$

In parenthesis OR and statistical significance compared to 1991 references

and girls was demonstrated in previous studies (Vignerová et al. 2006b, Vignerová et al. 2007). The goal of our study was to analyze changes in the prevalence of underweight, overweight, and obesity among Czech children in relation to an accelerated development of individuals rather than changes in lifestyle and socio-economic conditions that have occurred in the Czech society within the past several decades.

Table 5 The prevalence of underweight, normal weight, overweight, and obesity among girls by age groups in 1951, 1981, and 2001 as compared to the 1991 Czech References (Lhotská et al. 1993)

Age years	Numbers	BMI categories (%, OR)			
		<10th percentile Underweight	10th–90th percentile Normal	90th percentile < Overweight and obese	97th percentile< Obese
1951 survey					
3.00–5.99	8,721	5.6 [0.60 **]	84.2	10.2 [1.09 n.s.]	3.3
6.00–10.99	12,809	4.6 [0.46 **]	90.2	5.2 [0.52 **]	1.5
11.00–14.99	17,734	7.9 [0.84 **]	84.9	7.2 [0.76 **]	1.7
15.00–17.99	4,987	3.7 [0.41 **]	81.7	14.6 [1.61 **]	3.1
1981 survey					
3.00–5.99	8,174	11.7 [1.33 **]	79.3	9.0 [1.02 n.s.]	3.1
6.00–10.99	11,480	7.4 [0.80 **]	83.1	9.4 [1.02 n.s.]	3.3
11.00–14.99	9,288	8.4 [0.95 n.s.]	79.4	12.2 [1.38 **]	4.2
15.00–17.99	8,412	6.7 [0.74 **]	81.5	11.8 [1.30 **]	3.4
2001 survey					
3.00–5.99	2,029	13.1 [1.57 **]	75.3	11.6 [1.38 **]	5.0
6.00–10.99	5,931	8.0 [0.92 n.s.]	77.9	14.1 [1.63 **]	5.6
11.00–14.99	6,376	10.3 [1.20 **]	77.4	12.2 [1.42 **]	4.4
15.00–17.99	7,896	13.3 [1.53 **]	78.2	8.5 [0.98 n.s.]	2.5

n.s. non significant

*$p < 0.05$

**$p < 0.01$

In parenthesis OR and statistical significance compared to 1991 references

Table 6 BMI categories of children in 2001 by age groups-boys

Age years	Numbers	BMI categories (%)			
		90–97th percentile		97th percentile <	
		CR[I]	Cole[II]	CR[I]	Cole[II]
3.00–5.99	2,103	4.6	6.0	4.6	3.4
6.00–10.99	5,933	8.9	13.1	6.6	3.6
11.00–14.99	6,341	9.3	13.9	5.6	2.4
15.00–17.99	5,131	5.9	9.2	3.6	1.7

[I] Czech references 1991 (Lhotská et al. 1993)
[II] Cole et al. 2000

Given the primary goal of our study, our efforts to compare the rates of child underweight, overweight, and obesity between the four national surveys were somewhat limited. For instance, it is likely that the accelerated development of children and adolescents in recent years has influenced the number of individuals in the underweight, overweight, as well as obese weight category. The downward shift of adiposity rebound by more than 1 year since 1951 has changed the BMI values corresponding to the BMI percentile cutoffs among 3–6 year olds.

On the other hand, the shape of the weight-for-height curve has not changed substantially (Vignerová at al. 2007). This illustrates the importance of proper height adjustment in the historical population obesity assessments–especially when a non-negligible secular height trend is present. The number of underweight, overweight, as well as obese adolescents aged 11–15 has been likely influenced by the earlier puberty onset in the last several years (Vignerová et al. 2006a). Thus, a long-term comparison of the prevalence of underweight, overweight, and obesity in the Czech children population in our study was limited, especially among pre-school children and young adolescents.

Given the increased number of Czech school-aged children with excess adiposity, a gradual rise in the prevalence of overweight and obesity among Czech adolescents would be expected. However, our study shows that there is a clear trend of decreasing prevalence of overweight and obesity and increasing prevalence of underweight among girls aged 14 and older between 1951 and 1991. Because these findings cannot be influenced by the earlier occurrence of puberty, the results clearly indicate

that older adolescent girls used to be more robust than in the present time. Our findings are also consistent with previous research indicating that the number of mothers of children investigated during the Czech National Anthropological Surveys whose BMI was below 20 increased from 4.6% in 1951 to 13.5% in 2001. On the contrary, the rate of mothers whose BMI was over 30 decreased from 45% in 1951 to 27.6% in 2001. (Vignerová et al. 2006b).

Previous research suggests that child obesity is strongly associated with low socio-economic status and education, high parental BMI, limited breastfeeding, high birth weight, and other variables (Lioret et al. 2007; Owen et al. 2005; Padez et al. 2005; WHO 2007). While these factors could be contributing to the increased prevalence of overweight and obesity among Czech school-aged children, recent studies demonstrated that the educational level of Czech parents have been increasing, and the socio-economic and lifestyle differences have begun to diminish between urban and rural areas of the Czech Republic in recent years (Vignerová et al. 2006b). In addition, positive trends in terms of obesity prevention have been identified in the Czech Republic, including increased length of exclusive breastfeeding (Vignerová et al. 2006b). While further research in this area is warranted, it is likely that a combination of lifestyle, behavioral, and socio-economic factors are responsible for the changes in the prevalence of overweight and obesity among Czech children in recent decades. Although the prevalence of child overweight is clearly increasing among Czech children in certain age categories, it is important to note that the rates of overweight and obesity among 5–17-year-old children

Table 7 BMI categories of children in 2001 by age groups-girls

Age years	Numbers	BMI categories (%)			
		90–97th percentile		97th percentile <	
		CR[a]	Cole[b]	CR[a]	Cole[b]
3.00–5.99	2029	6.6	9.6	5.0	3.3
6.00–10.99	5931	8.5	13.4	5.6	3.2
11.00–14.99	6376	7.8	10.4	4.4	1.6
15.00–17.99	7896	6.0	6.9	2.5	0.8

[a] Czech references 1991 (Lhotská et al. 1993)
[b] Cole et al. 2000

remain relatively low (13% in 2001) compared to 32% in the US and 19% in Europe for children in the same age category (Lobstein et al. 2004).

Because the last National Anthropological Survey was conducted in 2001, the Lifestyle and Obesity Survey was implemented in 2005 in order to determine the current prevalence of overweight and obesity among Czech children and thus update the 2001 anthropometric data (Kunešová et al. 2007). The Lifestyle and Obesity Survey examined a total of 1,417 children and adolescents aged 6–18 years (Kunešová et al. 2007). The results of the survey identified an increasing trend towards overweight and obesity among Czech children, especially in the age category of 6–11year-old individuals (33.5% among boys compared to 16.5% in 2001; 37.7% among girls compared to 16.6% in 2001). Given the drastic increase in the prevalence of overweight and obesity reported by the Obesity and Lifestyle Survey, however, it is likely that the validity of the survey results was influenced by several factors, including a relatively small sample size and the use of entirely different methodology compared to the National Anthropological Surveys. Thus, the prevalence of overweight and obesity found in the 2005 Obesity and Lifestyle Survey cannot be directly compared to the results of the National Anthropological Surveys that utilize the same methodology and are conducted every 10 years in the Czech Republic.

Given the gradual increase in the prevalence of child overweight and obesity in certain age categories, it is critical to continue monitoring weight-related trends among children population in the Czech Republic in the upcoming years. The National Committee for Obesity, founded by the Ministry of Health in the Czech Republic, is currently developing new methodological approaches for screening overweight and obese children in the Czech Republic. The methodology is intended for pediatricians who complete mandatory preventive screening of children and adolescents on a regular basis.

The Czech Republic is also considering the implementation of the new growth standards for children under the age of 5 that were developed by the World Health Organization (WHO 2006). The implementation of the WHO standards would allow for direct comparisons of underweight, overweight, and obesity rates between Czech children and children from other countries. Finally, public health efforts are warranted in order to improve food choices, increase physical activity, and emphasize the importance of other effective measures against obesity such as long-term breastfeeding (Reilly 2007; Owen et al. 2005; WHO 2007).

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